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(54) [Title of the Invention] LIQUID CRYSTAL DISPLAY DEVICE

(57) [Abstract]

[Task] To provide a liquid crystal display device in which the responsiveness of the liquid crystal display is increased without significantly changing the conventional structure, and which can prevent a blurred display and image tailing even when a dynamic image is displayed.

[Means to solve] A vertical scanning period, which does not include the vertical blanking period of a liquid crystal display unit 12, is taken as a vertical period 1, and this vertical period is divided into four scanning periods. The scanning order of the four scanning periods is made corresponding to the arrangement order of four light emitting regions 33-1, 33-2, 33-3 and 33-4. These regions are controlled respectively by a turn-on control circuit 35 so as to emit light during a T1/4 period. Any one of discharge lamps 34-1, 34-2, 34-3 and 34-4 provided for each of respective light emitting regions 33-1, 33-2, 33-3 and 33-4 is turned on for only one quarter of the vertical period following the three quarters of the vertical period from the write timing of the liquid crystal display unit 12, and turned off during the remaining three quarters of the vertical period.

[Scope of the Patent Claims]

[Claim 1] A liquid crystal display device, characterized as comprising:

a liquid crystal display unit comprising a plurality of signal lines and a plurality of scanning lines that are arranged so as to cross each other, a signal line driver circuit for display data writing with respect to each signal line, and a scanning line driver circuit for scanning with respect to each said scanning line; and

a backlight having a light-emitting region divided into N sections with respect to the vertical scanning direction and turn-on control circuits for the light-emitting regions, wherein those turn-on control circuits successively turn on and turn off the N light emitting regions synchronously with a vertical synchronization signal of said light emitting display unit so as to illuminate said liquid crystal display unit.

[Claim 2] A liquid crystal display device according to claim 1, characterized in that, in the relationship in which a vertical scanning period, which does not include a vertical blanking period of the liquid crystal display unit, is taken as a vertical period T1, this vertical period T1 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of the N light emitting regions,

the light emitting region arranged in the next stage is caused to emit light within a T1/N period from the point in time at which the scanning of the scanning period corresponding to the selected light emitting region was started.

[Claim 3] A liquid crystal display device according to claim 1, characterized in that, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions,

the light emitting region arranged in the next stage is caused to emit light within a T2/N period from the point in time at which the scanning of the scanning period corresponding to the selected light emitting region was started.

[Claim 4] A liquid crystal display device according to claim 1, characterized in that, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions,

the selected light emitting region is caused to emit light within an almost T2/N period from the point in time at which half of the scanning of the scanning period corresponding to the light emitting region arranged at a stage preceding that of the selected light emitting region has elapsed.

[Claim 5] A liquid crystal display device according to claim 1, characterized in that, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions,

the light emitting region arranged in the next stage is caused to emit light within a T2/2N period from the point in time at which half of the scanning of the scanning period corresponding to the selected light emitting region has elapsed.

[Claim 6] A liquid crystal display device according to claim 1, characterized in that, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions,

the light emitting region arranged in the next stage is caused to emit light within a 2T2/N period from the point in time at which the scanning of the scanning period corresponding to the selected light emitting region was started.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Pertains] The present invention relates to a liquid crystal display device having a backlight and advantageously suitable for displaying dynamic images.

[0002]

[Prior Art] Dynamic images such as TV broadcasting or DVD can be projected on flat panel display devices such as monitors of various types and personal computers. Liquid crystal display devices, which are small and lightweight devices, have been widely used for flat panel display devices of this type.

[0003] However, if a dynamic image is projected on a conventional liquid crystal display device, specific properties of liquid crystals make it impossible to obtain a sufficient responsiveness and blurred images with tailing are displayed. Liquid crystal display elements based on new operation principles, for example, elements using ferroelectric liquid crystals and antiferroelectric liquid crystals, have been researched and developed as means for resolving the above-described problems. With the new liquid crystal display elements of such new types, a liquid crystal layer must be produced that has a thickness that is significantly less than that of conventional liquid crystal display elements and the control of gap and stretching over glass has created problems in the production process.

[0004] In addition to liquid crystal display elements, there are also plasma displays and cathode ray tubes (CRT) etc, but they are bulky and have high power consumption.

[0005]

[Problems to be Resolved by the Present Invention] Thus, the following problems have been encountered: with conventional liquid crystal display devices, sufficient responsiveness cannot be obtained due to specific properties of liquid crystals, liquid crystal display devices based on new operation principles are difficult to produce, and the devices other than those using liquid crystals are bulky and have high power consumption.

[0006] It is the object of the present invention to resolve the above-described problems and to provide a liquid crystal display device in which the responsiveness of the liquid crystal display is increased without significantly changing the conventional structure, and which can prevent a blurred display and image tailing even when a dynamic image is displayed.

[0007]

[Means to Resolve the Problems] The present invention provides a liquid crystal display device comprising a liquid crystal display unit comprising a plurality of signal lines and a plurality of scanning lines that are arranged so as to cross each other, a signal line driver circuit for display data writing with respect to each signal line, and a scanning line driver circuit for scanning with respect to each said scanning line, and a backlight having a light-emitting region divided into N sections with respect to the vertical scanning direction and turn-on control circuits for the light-emitting regions, wherein those turn-on control circuits successively turn on and turn off the N light emitting regions synchronously with a vertical synchronization signal of the light emitting display unit in order to illuminate the liquid crystal display unit.

[0008] Furthermore, in the relationship in which a vertical scanning period, which does not include a vertical blanking period of the liquid crystal display unit, is taken as a vertical period T1, this vertical period T1 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of the N light emitting regions, the light emitting region arranged in the next stage is caused to emit light within a T1/N period from the point in time at which the scanning of the scanning period corresponding to the selected light emitting region was started.

[0009] Moreover, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions, the light emitting region arranged in the next stage is caused to emit light within a T2/N period from the point in time at which the scanning of the scanning period corresponding to the selected light emitting region was started.

[0010] Furthermore, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions, the selected light emitting region is caused to emit light within an almost T2/N period from the point in time at which half of the scanning of the scanning period corresponding to the light emitting region arranged at a stage preceding that of the selected light emitting region has elapsed.

[0011] Moreover, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions, the light emitting region arranged in the next stage is caused to emit light within a T2/2N period from the point in time at which half of the scanning of the scanning period corresponding to the selected light emitting region has elapsed.

[0012] Moreover, in the relationship in which a period obtained by adding a blanking period to a vertical scanning period of the liquid crystal display unit is taken as a vertical period T2, this vertical period T2 is divided into N scanning periods, and the scanning order of the N scanning periods is made corresponding to the arrangement order of N light emitting regions, the light emitting region arranged in the next stage is caused to emit light within a 2T2/N period from the point in time at which the scanning of the scanning period corresponding to the selected light emitting region was started.

[0013] Successively turning on and off the N light emitting regions synchronously with the vertical synchronization signal of the liquid crystal display unit increases the responsiveness of the liquid crystal display and eliminates image tailing during dynamic image display, almost without change to the conventional structure.

[0014]

[Embodiments of the Present Invention] An embodiment of the liquid crystal display device in accordance with the present invention will be explained below with reference to the appended drawings.

[0015] As shown in Fig. 1, the liquid crystal display device uses thin-film transistors, for example, of 640 x 480 x RGB dots, and comprises a signal input terminal 11 for inputting video signals and synchronization signals.

[0016] Furthermore, the liquid crystal display device has a liquid crystal display unit 12 and a backlight unit 13. The liquid crystal display unit 12 has a plurality (640 x RGB) of signal lines 15 and a plurality (480) of scanning lines 16 that are arranged so as to be perpendicular to each other.

[0017] Furthermore, each signal line 15 is provided with a signal driver circuit 18 for display data writing. Those signal line driver circuits 18 have a shift register 19, a latch 20, and a D/A conversion circuit 21 for each signal line 15, and the display data DATA are successively retrieved into each latch 20 when the shift register 19 inputs a timing pulse STH and a shift clock $\phi 1$. If the display data DATA are accumulated in all of the latches 20, a horizontal synchronization signal $\phi 2$ is received and the accumulated display data are outputted into the D/A conversion circuit 21 where they are analog converted and then outputted to the corresponding signal line 15 via the buffer 22.

[0018] Furthermore, each scanning line 16 is provided with a scanning line driver circuit 23 for scanning. The scanning line driver circuits 23 comprise a shift register 24 and a switch circuit 25 having switching elements 25a, 25b provided for each scanning line. Among them, the shift register 24 successively shift the scanning timing pulses by receiving the scanning timing pulse (vertical synchronization signal) STV and scanning shift clock (horizontal scanning signal) $\phi 2$. When a scanning timing pulse STV is inputted to the switch circuit 25, a voltage Vg2 is selected by the switching element 25b, and when the scanning timing pulse STV is not inputted, a voltage Vg1 is selected by the switching element 25a and outputted to the corresponding scanning line 16. Thus, in each scanning line 16, a scanning pulse is outputted per each one line.

[0019] Pixel electrodes 27 are provided via thin film transistors (26) for pixel drive in the intersection zones of the signal lines 15 and scanning lines 16. Each pixel electrode 27 faces a common electrode 29 via a liquid crystal layer 28, and an auxiliary capacitance 30 is connected in parallel to the corresponding pixel electrode 27, liquid crystal layer 28, and common electrode 29. A thin twist nematic (TN) liquid crystal layer or ferroelectric liquid crystal layer may be used as the liquid crystal layer 28.

[0020] A signal voltage outputted into the corresponding signal line 15 is written into the pixel composed of the aforementioned pixel electrode 27, liquid crystal layer 28, and common electrode 29 by outputting a scanning pulse into the corresponding scanning line 16.

[0021] Furthermore, the backlight unit 13 comprises a backlight 33 for illuminating the display surface of the liquid crystal display unit 12. The backlight 33 has N, for example, four rectangular light emitting regions 33-1, 33-2, 33-3, 33-4 divided in the vertical scanning direction of the liquid crystal display unit 12, and discharge lamps 34-1, 34-2, 34-3, 34-4 are provided for each light emitting region 33-1, 33-2, 33-3, 33-4.

[0022] A turn-on control circuit 35 is provided for each discharge lamp 34-1, 34-2, 34-3, 34-4. The turn-on control circuit 35 has a counter 36 for dividing, a shift register 37, and an inverter 38 for turn-on drive. The scanning shift clock $\phi 2$ is divided by the counter 36, and the signals that were divided are successively applied to each inverter 38 synchronously with the scanning timing pulse STV by the shift register 37. As a result, the discharge lamps 34-1, 34-2, 34-3, 34-4 provided respectively for each of four light emitting regions 33-1, 33-2, 33-3, 33-4 are successively turned on and off one by one

with the prescribed period. Therefore, the backlight 33 conducts successive scan emission for each of N light emitting regions 33-1, 33-2, 33-3, 33-4.

[0023] The turn-on and turn-off operation of light emitting regions 33-1, 33-2, 33-3, 33-4 will be explained below with reference to the timing chart shown in Fig. 2.

[0024] First, the vertical scanning period, which does not include a vertical blanking period of the liquid crystal display unit 12, is taken as a vertical period T1, and this vertical period T1 is divided into four scanning periods T11, T12, T13, T14. The scanning order of the four scanning periods T11, T12, T13, T14 is made corresponding to the arrangement order of the four light emitting regions 33-1, 33-2, 33-3, 33-4.

[0025] The liquid crystal display device 12 comprises 480 scanning lines 16, and the scanning shift clock $\phi 2$, which is also a horizontal synchronization signal, successively applies a pulse voltage to those 480 scanning lines 16 and scans them by using the scanning line driver circuit 23.

[0026] Here, a vertical scanning period, which does not include the vertical blanking period, i.e., the interval from the 481st pulse to the 525th pulse, that is the interval from the 1st to the 480th pulse that is required for scanning 480 scanning lines 16, is taken as a vertical period T1. The vertical period T1 is divided according to the number $N = 4$ of the light emitting regions, and the four divided periods include a scanning period T11, which is a period for scanning the 1st to 120th scanning lines, a scanning period T12, which is a period for scanning the 121st to 240th scanning lines, a scanning period T13, which is a period for scanning the 241st to 360th scanning lines, and a period T14 for scanning the 361st to 480th scanning lines. The scanning order of the scanning periods is made corresponding to the arrangement order of the four light emitting regions 33-1, 33-2, 33-3, 33-4.

[0027] Thus, the scanning period T11, which is the first scanning period in the order of scanning, corresponds to the light emitting region 33-1, which is the first light emitting region in the order of arrangement. Likewise, the scanning period T12 corresponds to the light emitting region 33-2, the scanning period T13 corresponds to the light emitting region 33-3, and the scanning period T14 corresponds to the light emitting region 33-4.

[0028] In such a relationship, the scanning line driver circuit 23 and the turn-on control circuit 35 of the backlight 33 are synchronized with the scanning timing pulse STV of a 16 ms period, and each light emitting region 33-1, 33-2, 33-3, 33-4 is controlled by the turn-on control circuit 35 so that, for example, if the scanning of the scanning period T11 corresponding to a selected light emitting region 33-1 is started, then the light emitting region 33-2 arranged in the next stage will emit light within the T1/4 period from this point in time, that is, within a period of scanning 120 scanning lines 16.

[0029] Likewise, the light emitting region 33-3 of the next stage will be controlled by the turn-on control circuit 35 so as to emit light with a T1/4 period following the scanning start of the scanning period T12 corresponding to the light emitting region 33-2, the light

emitting region 33-4 of the next stage will emit light with a T1/4 period following the scanning start of the scanning period T13 corresponding to the light emitting region 33-3, and the light emitting region 33-1 of the next stage will emit light with a T1/4 period following the scanning start of the scanning period T14 corresponding to the light emitting region 33-4.

[0030] Those light emission periods T1/4 are set by dividing the scanning shift clock $\phi 2$ by 120 pulses with the counter 36 constituting the turn-on control circuit 35. Furthermore, the four light emitting regions can be successively turned on and off in the prescribed intervals T1/4 and the so-called scan light emission can be induced by successively applying to the four inverters 38 the signals divided for each T1/4 period synchronously with the vertical synchronization signal STV by the shift register 37.

[0031] In other words, any of the discharge lamps 34-1, 34-2, 34-3, 34-4 provided for each light emitting region will be turned on within one quarter of the scanning period following the three quarters of the scanning period from the read timing of the liquid crystal display device 12.

[0032] In such a liquid crystal display device in which the backlight 33 was divided into N light emitting regions and successive scan light emission thereof was induced, highly dynamic images obtained by projecting the television (TV) images and digital video disk (DVD) images could be clearly observed without tailing. In particular, the text of running subtitles could be displayed without tailing, regardless of the movement speed of the subtitles. Furthermore, a uniform display could be obtained in which the four discharge lamps 34-1, 34-2, 34-3, 34-4 were not remarkable and did not degrade the display.

[0033] The second embodiment will be described below with reference to the timing chart shown in Fig. 3.

[0034] In the second embodiment, the discharge lamps 34-1, 34-2, 34-3, 34-4 of the corresponding light emitting regions 33-1, 33-2, 33-3, 33-4 are also turned on in the vertical blanking period.

[0035] Here, the period obtained by adding the vertical blanking period, which is a period from the 481st pulse to the 525th pulse, to the vertical scanning period of the liquid crystal display device 12, which is a period from the 1st to the 480th pulse required for the operation of the 480 scanning lines 16, is taken as the vertical period T2. The vertical period T2 is divided according to the number N = 4 of the light emitting regions, and the four divided periods include a scanning period T21, which is a period for scanning the scanning lines from the 1st scanning line to the 131st scanning line, a scanning period T22, which is a period for scanning the 132nd to 262nd scanning lines, a scanning period T23, which is a period for scanning the 263rd to 393rd scanning lines, a scanning period T24 for scanning the 394th to 480th scanning lines, and a period to the 524th pulse, which is the vertical blanking period. The scanning order of the scanning periods is made corresponding to the arrangement order of the four light emitting regions 33-1, 33-2, 33-3, 33-4.

[0036] Thus, the scanning period T21, which is the first scanning period in the order of scanning, corresponds to the light emitting region 33-1, which is the first light emitting region in the order of arrangement. Likewise, the scanning period T22 corresponds to the light emitting region 33-2, the scanning period T23 corresponds to the light emitting region 33-3, and the scanning period T24 corresponds to the light emitting region 33-4.

[0037] In such a relationship, the scanning line driver circuit 23 and the turn-on control circuit 35 of the backlight 33 are synchronized with the scanning timing pulse STV of a 16 ms period, and each light emitting region 33-1, 33-2, 33-3, 33-4 is controlled by the turn-on control circuit 35 so that, for example, if the scanning of the scanning period T21 corresponding to a selected light emitting region 33-1 is started, then the light emitting region 33-2 arranged in the next stage will emit light within the T2/4 period from this point in time, that is, within a period of scanning 131 scanning lines 16.

[0038] Likewise, the light emitting region 33-3 of the next stage will be controlled by the turn-on control circuit 35 so as to emit light with a T2/4 period following the scanning start of the scanning period T22 corresponding to the light emitting region 33-2, the light emitting region 33-4 of the next stage will emit light with a T2/4 period following the scanning start of the scanning period T23 corresponding to the light emitting region 33-3, and the light emitting region 33-1 of the next stage will emit light with a T2/4 period following the scanning start of the scanning period T24 corresponding to the light emitting region 33-4.

[0039] Those light emission periods T2/4 are set by dividing the scanning shift clock $\phi 2$ by 131 pulses with the counter 36 constituting the turn-on control circuit 35.

[0040] When television (TV) images and digital video disk (DVD) images were projected on the liquid crystal display device of such a configuration, highly dynamic images could be clearly observed without tailing, in the same manner as in the first embodiment. In particular, in the second embodiment, because the discharge lamp 34-1 of the light-emitting region 33-1 is turned on also in the vertical blanking period, the brightness can be increased.

[0041] The third embodiment will be described below with reference to the timing chart shown in Fig. 4.

[0042] In the third embodiment, the scanning start timing for a scanning period corresponding to a selected light emitting region is taken as a center, and the corresponding discharge lamps 34-1, 34-2, 34-3, 34-4 are turned on within almost one quarter of the period before and after the center.

[0043] In this case as well, the period obtained by adding the vertical blanking period to the vertical scanning period of the liquid crystal display device 12 is taken as the vertical period T2, the vertical period T2 is divided according to the number $N = 4$ of the light emitting regions into four scanning periods T21, T22, T23, T24, and the scanning order

thereof is made corresponding to the arrangement order of the four light emitting regions 33-1, 33-2, 33-3, 33-4.

[0044] Thus, the scanning period T21, which is the first scanning period in the order of scanning, corresponds to the light emitting region 33-1, which is the first light emitting region in the order of arrangement. Likewise, the scanning period T22 corresponds to the light emitting region 33-2, the scanning period T23 corresponds to the light emitting region 33-3, and the scanning period T24 corresponds to the light emitting region 33-4.

[0045] In such a relationship, of the light emitting regions 33-1, 33-2, 33-3, 33-4, a selected light emitting region 33-2 is caused to emit light within 131 pulses of the T2/4 period from the point in time at which half, for example 65 pulses, of the scanning of the scanning period T21 corresponding to the light emitting region 33-1 arranged in the previous stage before the selected light emitting region 33-2 has elapsed.

[0046] Likewise, the light emitting region 33-3 emits light within 131 pulses from the point in time at which half of the scanning of the scanning period T22 corresponding to the light emitting region 33-2 has elapsed, and the light emitting region 33-4 emits light within 131 pulses from the point in time at which half of the scanning of the scanning period T23 corresponding to the light emitting region 33-3 has elapsed. Furthermore, the light emitting region 33-1 is controlled by the turn-on control circuit 35 so as to emit light within 132 pulses from the point in time at which half of the scanning of the scanning period T24 corresponding to the light emitting region 33-4 has elapsed.

[0047] Thus, in other words, for example, the scanning start timing for the scanning period T22 corresponding to a selected light emitting region 33-2 is taken as a center, and the corresponding discharge lamps 34-1, 34-2, 34-3, 34-4 are turned on with 131 pulses representing almost 1/4 of the vertical period before and after the center. For the light emitting region 33-1 only, this period is 132 pulses.

[0048] With this configuration as well, when TV images and DVD images were projected, highly dynamic images could be clearly observed without tailing.

[0049] The fourth embodiment will be described below with reference to the timing chart shown in Fig. 5.

[0050] In the fourth embodiment, the discharge lamps 34-1, 34-2, 34-3, 34-4 provided in the light emitting regions 33-1, 33-2, 33-3, 33-4 are turned on successively within 1/8 of the vertical period.

[0051] In this case as well, the period obtained by adding the vertical blanking period to the vertical scanning period of the liquid crystal display device 12 is taken as the vertical period T2, the vertical period T2 is divided according to the number N = 4 of the light emitting regions into four scanning periods T21, T22, T23, T24, and the scanning order thereof is made corresponding to the arrangement order of the four light emitting regions 33-1, 33-2, 33-3, 33-4.

[0052] In such a relationship, the light emitting regions 33-1, 33-2, 33-3, 33-4 are controlled by the turn-on control circuit 35 so that if, for example, a light emitting region 33-1 is selected, then the light emitting region 33-2, which is arranged in the next stage, emits light within 66 pulses from the 66th scanning line to the 131st scanning line, which is the T2/2N period and represents the 1/8 of the vertical period from the point in time at which half of the scanning of the scanning period T21 corresponding to the selected light emitting region 33-1, that is, 65 pulses of the scanning from the 1st scanning line to the 65th scanning line, has elapsed.

[0053] Likewise, the control with the turn-on control circuit 35 is so conducted that the light emitting region 33-3 of the next stage emits light from the point in time at which half of the scanning of the scanning period T22 corresponding to the light emitting region 33-2 has elapsed, the light emitting region 33-4 of the next stage emits light from the point in time at which half of the scanning of the scanning period T23 corresponding to the light emitting region 33-3 has elapsed, and the light emitting region 33-1 of the next stage emits light within 66 pulses, which is 1/8 of the vertical period, from the point in time at which half of the scanning of the scanning period T24 corresponding to the light emitting region 33-4 has elapsed.

[0054] In this case as well, when TV images and DVD images were projected, highly dynamic images could be clearly observed without tailing. Furthermore, because the turn-on time per one discharge lamp 34-1, 34-2, 34-3, 34-4 is short, the brightness is decreased, but the contour of the dynamic image becomes accordingly brighter.

[0055] The fifth embodiment will be described below with reference to the timing chart shown in Fig. 6.

[0056] In the fifth embodiment, the discharge lamps 34-1, 34-2, 34-3, 34-4 provided in the light emitting regions 33-1, 33-2, 33-3, 33-4 are turned on successively within almost 1/2 of the vertical period.

[0057] In this case as well, the period obtained by adding the vertical blanking period to the vertical scanning period of the liquid crystal display device 12 is taken as the vertical period T2, the vertical period T2 is divided according to the number N = 4 of the light emitting regions into four scanning periods T21, T22, T23, T24, and the scanning order thereof is made corresponding to the arrangement order of the four light emitting regions 33-1, 33-2, 33-3, 33-4.

[0058] In such a relationship, the light emitting regions 33-1, 33-2, 33-3, 33-4 are controlled by the turn-on control circuit 35 so that if, for example, the scanning of the scanning period T21 corresponding to the selected light emitting region 33-1 is started, the light emitting region 33-2 arranged in the next stage emits light, for example, within 262 pulses of the scanning from the 1st scanning line to the 262nd scanning line of the 2T2/N period, which is 1/2 of the vertical period, from this point in time.

[0059] Likewise, the control with the turn-on control circuit 35 is so conducted that the light emitting region 33-3 of the next stage emits light within 262 pulsed, which is 1/2 of the vertical period, following the scanning start of the scanning period T22 corresponding to the light emitting region 33-2, the light emitting region 33-4 of the next stage emits light within 262 pulsed, which is 1/2 of the vertical period, following the scanning start of the scanning period T23 corresponding to the light emitting region 33-3, and only the light emitting region 33-1 emits light within 263 pulses, following the scanning start of the scanning period T24 corresponding to the light emitting region 33-4.

[0060] In this case as well, when TV images and DVD images were projected, highly dynamic images could be clearly observed without tailing. Furthermore, because the turn-on time per one discharge lamp 34-1, 34-2, 34-3, 34-4 is 1/2 of the vertical period, the contour of the dynamic image was somewhat blurred, but the brightness was greatly increased.

[0061] In a comparative example, the scan light emission control function was removed from the turn-on control circuit 35 of the backlight unit 13 shown in Fig. 1 and the discharge lamps 34-1, 34-2, 34-3, 34-4 were continuously turned on by the conventional method. In this case, image tailing was observed and blurred images were obtained in the TV images and DVD images.

[0062]

[Effect of the Invention] In accordance with the present invention, the responsiveness of liquid crystals is increased by simple and inexpensive means, almost without change to the conventional liquid crystal structure. Therefore, a fine image can be obtained without tailing, even in a dynamic image display.

[Brief Description of the Drawings]

Fig. 1 is a circuit diagram illustrating an embodiment of the liquid crystal display device in accordance with the present invention.

Fig. 2 is a timing chart illustrating the turn-on timing of a backlight unit in the first embodiment.

Fig. 3 is a timing chart illustrating the turn-on timing of a backlight unit in the second embodiment.

Fig. 4 is a timing chart illustrating the turn-on timing of a backlight unit in the third embodiment.

Fig. 5 is a timing chart illustrating the turn-on timing of a backlight unit in the fourth embodiment.

Fig. 6 is a timing chart illustrating the turn-on timing of a backlight unit in the fifth embodiment.

[Explanation of Reference Symbols]

12 liquid crystal display unit

15 signal line
16 scanning line
18 signal line driver circuit
23 scanning line driver circuit
33 backlight
33-1, 33-2, 33-3, 33-4 light emitting regions
35 turn-on control circuit

FIG. 1

12 LIQUID CRYSTAL DISPLAY UNIT
13 BACKLIGHT UNIT
15 SIGNAL LINE
16 SCANNING LINE
18 SIGNAL DRIVER CIRCUIT
19 SHIFT REGISTER
20 Latch
23 SCANNING DRIVER CIRCUIT
24 SHIFT REGISTER
33 BACKLIGHT
33-1 LIGHT EMITTING REGION
33-2 LIGHT EMITTING REGION
33-3 LIGHT EMITTING REGION
33-4 LIGHT EMITTING REGION
35 TURN-ON CONTROL CIRCUIT
36 COUNTER
37 SHIFT REGISTER
38 INVERTER
39 INVERTER

FIG. 2

INPUT

OUTPUT
DISCHARGE LAMP 34-1
ON
OFF
DISCHARGE LAMP 34-2
ON
OFF
DISCHARGE LAMP 34-3
ON
OFF
DISCHARGE LAMP 34-4
ON

OFF

FIG. 3

INPUT

OUTPUT

DISCHARGE LAMP 34-1
ON
OFF
DISCHARGE LAMP 34-2
ON
OFF
DISCHARGE LAMP 34-3
ON
OFF
DISCHARGE LAMP 34-4
ON
OFF

FIG. 4

INPUT

OUTPUT
DISCHARGE LAMP 34-1
ON
OFF
DISCHARGE LAMP 34-2
ON
OFF
DISCHARGE LAMP 34-3
ON
OFF
DISCHARGE LAMP 34-4
ON
OFF

FIG. 5

INPUT

OUTPUT
DISCHARGE LAMP 34-1
ON

OFF
DISCHARGE LAMP 34-2
ON
OFF
DISCHARGE LAMP 34-3
ON
OFF
DISCHARGE LAMP 34-4
ON
OFF

FIG. 6

INPUT

OUTPUT
DISCHARGE LAMP 34-1
ON
OFF
DISCHARGE LAMP 34-2
ON
OFF
DISCHARGE LAMP 34-3
ON
OFF
DISCHARGE LAMP 34-4
ON
OFF

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CERTIFICATION

This is to certify that the attached, to the best of my knowledge and belief, is a true and accurate translation into English of Patent JP 11-202285, originally written in Japanese.

Glenn Cain
Manager of Legal Translation Services
The LanguageWorks, Inc.

Sworn to and subscribed before me
This Thirteenth day of April, 2006

Notary Public

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Commission Expires July 16, 2007